

THE TROGLOBITIC MILLIPED GENUS ZYGNOPUS
(CHORDEUMIDA, CONOTYLIDAE,
TRICHOPETALINAE)

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In many of the caves from Virginia south to Alabama and Georgia and west to Missouri, there are small, depigmented, eyeless millipeds of two genera of the family Conotylidae. *Sco-terpes*, the larger and more complex of these genera, occurs in the southern part of the area and *Zygonopus* in the northern part. Their ranges are not known to overlap. Specimens occur in remote regions of caves, where they are found crawling on damp floors, walls, or pieces of organic matter such as wood, paper, or the excrement of other cave animals. Neither genus is known to have epigeal forms.

ACKNOWLEDGMENTS

I am indebted to the following for their generous cooperation: Dr. Carl H. Krekeler, whose collection furnished material for my introductory work on the genus; Mr. H. F. Loomis, who contributed a topotype of *Zygonopus whitei*; Mr. Oscar P. Estes, who made a trip to Grand Caverns especially to collect specimens of the species described here as *Z. weyeri*; and to Dr. Thomas C. Barr, Jr., who contributed more than 200 specimens.

DEPOSITION OF SPECIMENS

The male holotypes and female paratypes of *Z. krekeri*, *Z. packardi*, and *Z. weyeri* will be deposited in the American Museum of Natural History. Topotypes or paratypes of all species will be deposited in the United States National Museum. The remaining specimens will be retained in the author's private collection. The location of the type specimens of *Z. whitei* is unknown.

KEY TO THE TROGLOBITIC GENERA OF THE TRICHOPETALINAE

1. Segmental setae of most body segments arranged in a forwardly curved row on each side of the dorsum. Fourth segment of the sixth legpair

- of the male bowed and the entire leg conspicuously thicker and longer than any others *Zygonopus* Ryder
2. Segmental setae of most body segments arranged in an oblique row on each side of the dorsum. Fourth segment of the sixth legpair of the male never bowed and the entire leg never longer than any other *Scoterpes* Cope

The epigean genus *Trichopetalum*, which is represented by species from Newfoundland to Colorado, appears to be the genus most closely related to *Zygonopus*. Epigean species of the Trichopetalinae tend to be more conservative than the troglodytic species, specimens of some species having been collected from sites more than 800 miles apart.

HISTORY

Because of their similarities in habitat and morphology, the histories of the genera *Zygonopus* and *Scoterpes* are interwoven. *Scoterpes* was proposed by E. D. Cope (1872) for *Spirostrephon copei* Packard 1871. *Zygonopus* was proposed by J. A. Ryder (1881) for a new species, *whitei*, described from specimens from Luray Cave that had previously been identified as *Spirostrephon copei*. Ryder recognized the importance of the enlarged sixth legs of the male as a generic character and published a poor figure of them; he did not describe the gonopods. A. S. Packard put *Scoterpes* and *Zygonopus* into the genus *Spirostrephon* in 1881, but later he recognized them both (1883), as did Jerome McNeill (1888). Packard (1883), like Ryder, miscounted the number of body segments, but he wrote a fairly good description of *Zygonopus*; he noted that the segmental setae are not as coarse or as long as they are in *Scoterpes*, described the gonopods, and later (1886) published figures of them. The form that he described is published here as a new species, *Zygonopus weyeriensi*s. In Charles H. Bollman's posthumously published work (1893), *Scoterpes* and *Zygonopus* were combined in one paper and listed as separate genera in another. Cook and Collins (1895) recognized both genera and gave detailed descriptions and figures of *Z. whitei*. H. F. Loomis (1939) called attention to the difference in the arrangement of the segmental setae in the two genera.

Genus *Zygonopus* Ryder

Zygonopus Ryder, 1881, Proc. U. S. Natl. Mus., vol. 3, no.

181, p. 527. Packard, 1883, Proc. Amer. Phil. Soc., vol. 21, pp. 194-195; 1886, Natl. Acad. Sci., vol. 4, p. 63. McNeill, 1888, Bull. Brookville Soc. Nat. Hist., no. 3, p. 9. Bollman, 1893, U. S. Natl. Mus., bull. 46, p. 158. Cook and Collins, 1895, Ann. N. Y. Acad. Sci., vol. 9, pp. 59-60. Loomis, 1939, Bull. Mus. Comp. Zool., vol. 86, no. 4, p. 182. Chamberlin and Hoffman, 1958, U. S. Natl. Mus., bull. 212, p. 103.

Scoterpes, Bollman, 1893, U. S. Natl. Mus., bull. 46, p. 121.

TYPE SPECIES: *Zygonopus whitei* Ryder, by monotypy.

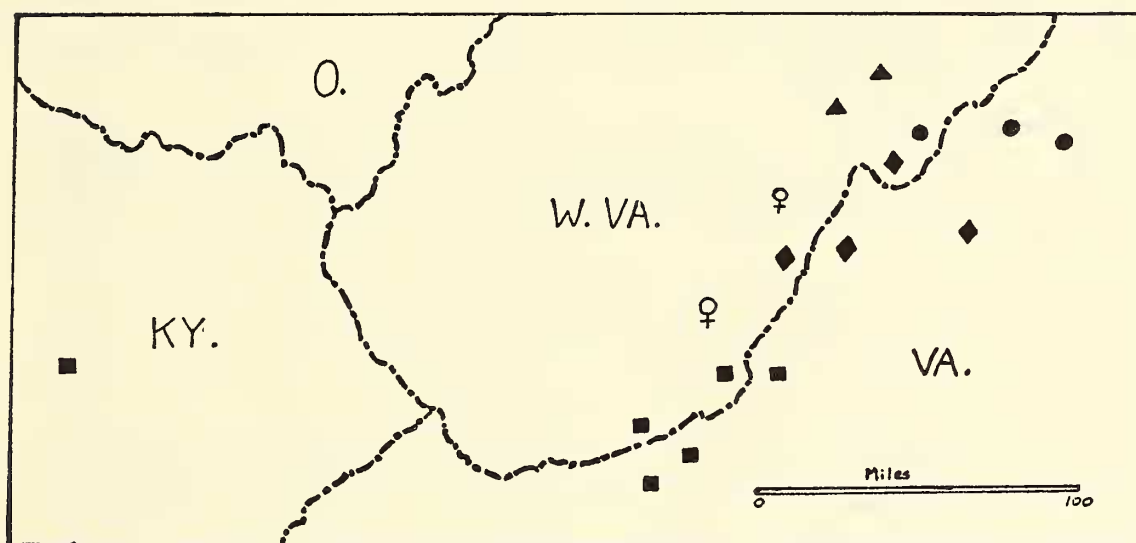


FIG. 1. Distribution of the known species of *Zygonopus*. The approximate location of collection sites of *Z. krekleri* is indicated by triangles, *Z. packardi* by squares, *Z. weyerienseis* by diamonds, and *Z. whitei* by filled circles. Records of specimens of undetermined species are indicated by the female symbol.

RANGE: Seventeen counties along the Virginia-West Virginia boundary and one county in east central Kentucky (fig. 1); the Kentucky record should be reexamined.

SPECIES: Four.

DIAGNOSIS: Trichopetalids of 30 body segments, of moderate length, depigmented, and similar to *Scoterpes* in the absence of ocelli and in the cave habitat, but nearer *Trichopetalum* in the structure of the gonopods, the length and arrangement of the segmental setae, and the shape of the paranota; distinguished especially by the enlarged and bowed sixth legs of the male.

Mentum undivided, the anterior margin straight, and the space between it and the lingual lamellae filled by a triangular membrane. Antennae slender. Exoskeleton thin. Dorsum smooth. Typical paranota with the an-

terio-lateral margin broadly rounded, the width about two-thirds the length. Segmental setae on most segments set in a curved row on each side of the dorsum, with the lateral seta on the caudal angle of the paranotum, the medial seta on the anterior margin of the paranotum, and the internal seta at the same level as the medial seta, but slightly farther from it than the lateral seta is; setae on the posterior segments arranged in a transverse row. Segmental setae acute, the length more than one-half the body width; setae shorter and finer than in *Scoterpes*. Posterior margin of metatergites very finely serrulated; lateral and ventral margins of segments more distinctly serrulated.

Sixth legpair of male longer and thicker than any others and with the fourth segment markedly bowed. No other legs anterior to the gonopods are greatly modified; the first and second are slightly reduced and the third through the fifth may be slightly swollen. Coxae of legpairs 10 and 11 with the usual glands.

Gonopods much as in *Trichopetalum*. Anterior gonopod with two coxites, which are either slender and spinous or broad and membranous. Anterior surface of coxa with a band or a large patch of closely placed, very small, scale-like setae and two groups of longer setae, one group of three setae along the median margin and the other group of several setae on the disto-lateral margin. Telopodite of anterior gonopod¹ thick, usually rectangular, shorter and narrower than the coxa, not visible from a ventral view *in situ*, and with no processes other than the one large and one or two smaller plumose branches that project ventrad between the telopodite and the coxa.

Posterior gonopod composed of two thickened, elongated segments, of which the second one is about one-third longer than the first, has no rudimentary segments at the apex, and usually has no terminal spine. Median surface of first segment with a rounded lobe, which has the opening of the coxal gland in it; base of first segment does not reach to the midline of the sternum. Sternum weak and without ventral lobes.

KEY TO THE SPECIES OF *Zygonopus* BASED ON THE MALE GONOPODS

1. Each anterior gonopod with a broad, membranous, median coxite and a longer, spinous, lateral coxite **Z. krekeleri**, new species
Each anterior gonopod with two spinous coxites, but no membranous coxite 2
2. The two coxites contiguous at the base; the median one long and distinctly curved and the lateral one about as long and slightly curved **Z. packardi**, new species
The two coxites not contiguous at the base; almost equal in length and in curvature 3

¹ Palmen (1953, p. 10) referred to the telopodite of the anterior gonopod of *Trichopetalum lunatum* as the "denticulate lamella" and found its connection with the gonopod obscure. In species of *Scoterpes*, in which the anterior gonopod has retained a more primitive condition than in some other genera, it is possible to see the attachment of the plumose branch to the telopodite.

3. Median margin of anterior gonopod almost vertical; median and disto-lateral coxal setae slightly sinuous **Z. whitei** Ryder
 Median margin of anterior gonopod either broadly rounded or forming a right angle; the median and disto-lateral coxal setae straight **Z. weyeri**ensis, new species

Zygonopus krekeleri stands distinctly apart from the other known species of the genus. The differences between *Z. packardi*, *Z. weyeri*ensis, and *Z. whitei* are mainly quantitative. When these three species were first studied, it appeared that subsequent collections might yield forms that would connect them. Then Dr. Barr's large collection with male specimens of three species from 12 additional caves was received. Some variations were found, but they are slight, and in no case can they be regarded as integrades between the species. The genus differs markedly from the related genus *Scoterpes*, in which the population of almost every cave is taxonomically distinct from that of any other cave.

Zygonopus whitei Ryder

Figures 2, 3.

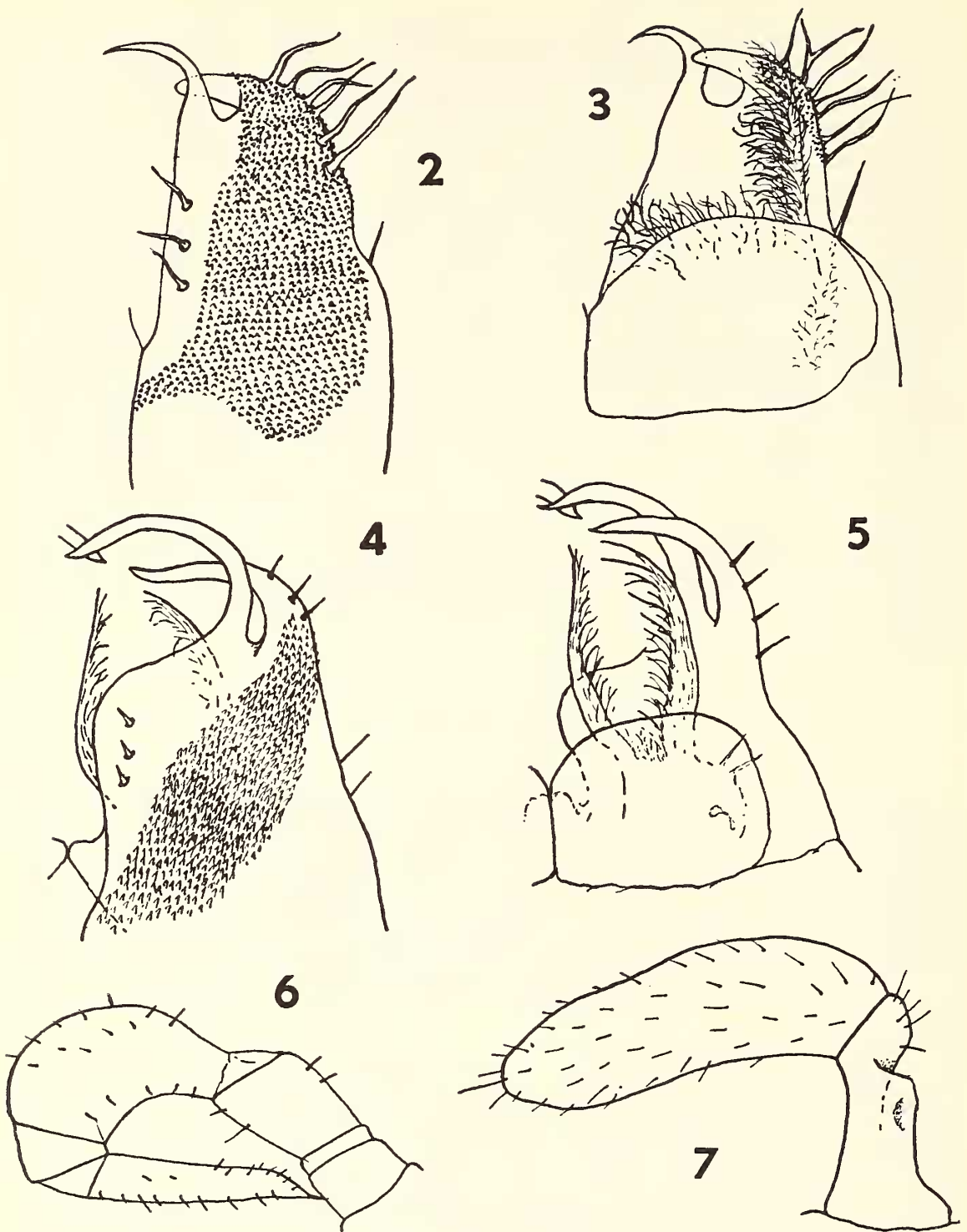
Zygonopus whitei Ryder, 1881, Proc. U. S. Nat. Mus., vol. 3, p. 527, figs. 1-3. Cook and Collins, 1895, New York Acad. Sci., vol. 9, pp. 60-62, pls. 1, 2, figs. 14-21. Loomis, 1939, Bull. Mus. Comp. Zool., vol. 86, no. 4, p. 182. Chamberlin and Hoffman (? *partim*), 1958, U. S. Natl. Mus., Bull. 212, p. 104.

Spirostrephon copei Packard. Packard, 1881, Amer. Nat., vol. 15, p. 231.

DIAGNOSIS: Distinguished by the characters of the anterior gonopod, especially the sinuous coxal setae and the two relatively short, spinous, subequal, mesially curved coxites. Very near *Z. weyeri*ensis, from which it can be distinguished by the following characters of the anterior gonopod: the shorter coxites, the almost straight median margin of the coxa, and the sinuous rather than straight coxal setae.

Body length about 8 or 9 mm. The sixth legpair of the male is inflated and bowed much as in *Z. weyeri*ensis (fig. 6), but the last segment is slightly plumper and bears more setae on the median surface.

Most of the anterior surface of the anterior gonopod (fig. 2) is covered with very fine, evenly spaced setae. The long setae in the median row of three and in the row of six or seven on the disto-lateral margin of the coxa are slightly sinuous and an occasional one is branched; in all other species these setae are straight and unbranched. The two coxites are not contiguous at the base; the median one is thinner and its apex is more acute than the lateral one. The telopodite, which can be seen from a pos-



FIGS. 2, 3. *Zygonopus whitei* Ryder. 2. Right anterior gonopod, anterior view. 3. Left anterior gonopod, posterior view. Drawn from male topotype.

FIGS. 4-7. *Zygonopus weyeri*ensis, new species. 4. Right anterior gonopod, anterior view. 5. Left anterior gonopod, posterior view. 6. Sixth leg. 7. Posterior gonopod. Drawn from male holotype.

terior view of the gonopod (fig. 3), is almost ovoid; the main plumose branch is finely divided and so short that it must be viewed from a posterior view of the gonopod; the two shorter plumose branches are almost entirely covered by the telopodite.

The posterior gonopod is composed of the usual two inflated, elongated segments and a terminal spine. Except for the spine, and the larger median lobe on the first segment, the appearance is very much as in *Z. weyeriensis* (fig. 7).

Cook and Collins (1895) reported that this species has "Irregular longitudinal wrinkles" on the dorsal surface of the body. I failed to find them.

TYPE LOCALITY: Luray Cave, Page County, Virginia.

RANGE: Caves in Page and Shenandoah Counties, Virginia; and Pendleton County, West Virginia. The report by Chamberlin and Hoffman (1958) of this species in Alleghany, Bath, Montgomery, and Roanoke Counties, Virginia, undoubtedly represents an error in determination, since these counties fall within the ranges of *Z. weyeriensis* and *Z. packardi*. The Pendleton County, West Virginia, records of Loomis (1939) are based on females and should be reexamined, since *Z. weyeriensis* also occurs in this county.

RECORDS: WEST VIRGINIA: Pendleton Co. Stratosphere Balloon Cave, Aug. 31, 1958, 6 ♂, 11 ♀, T. C. Barr, Jr. This cave is 100 yards from the entrance to Seneca Caverns, from which Loomis (1939) reported *Z. whitei*.

VIRGINIA: Shenandoah Co. Madden's Cave, New Market Station, Aug. 25, 1958, 2 ♀, T. C. Barr, Jr. Loomis (1939) identified specimens from the New Market Caves as *Z. whitei*.

***Zygonopus weyeriensis*, new species**

Figures 4-7

Zygonopus whitei Ryder. Packard, 1883, Proc. Amer. Philos. Soc., vol. 21, pp. 194-195; 1886, Natl. Acad. Sci., vol. 4, p. 64, pl. 7, figs. 1, 1a-1o

DIAGNOSIS: Distinguished by the characters of the anterior gonopod, especially the two relatively long, spinous, subequal, mesially curved coxites. Very near. *Z. whitei*, from which it can be distinguished by the following characters of the anterior gonopod: the longer coxites, the angular median margin of the coxa, and the straight rather than sinuous coxal setae. Distinguished from *Z. packardi* by the more evenly curved and more nearly equal coxites.

DESCRIPTION OF MALE HOLOTYPE: Length 10 mm., greatest body width 0.8

mm. Legpairs three through five are slightly inflated. The sixth legpair (fig. 6) is markedly inflated and longer than any other legs.

The coxal division of the anterior gonopod (fig. 4.) bears two spinous coxites, mesially curved, subequal in length and in curvature, the lateral one thicker, slightly separated at the base, and almost twice as long as the coxites of *Z. whitei*.

The coxal region is shorter than in *Z. whitei* and the median margin is broadly rounded. Most of its anterior surface is covered with minute, closely arranged, scale-like setae. Three longer, straight setae are set near the median margin and four or five on the disto-lateral margin at the base of the lateral coxite. The telopodite is relatively small, and the two sparsely divided plumose branches are almost the same length (fig. 5).

The posterior gonopod (fig. 7) is composed of two inflated, elongated segments. There is no terminal spine.

VARIATIONS: Males from other localities may differ from the holotype in the following characters: slightly smaller sixth legs, the median margin of the anterior gonopod in the form of a right angle instead of rounded, and with a minute terminal spine on the posterior gonopod.

TYPE LOCALITY: Grand Caverns, Augusta County, Virginia. This site was formerly known as Weyer's Cave.

RANGE: Caves in Augusta and Bath Counties, Virginia; and Greenbrier and Pendleton Counties, West Virginia.

RECORDS: VIRGINIA: Augusta Co.: Grand Caverns, Nov. 20, 1958, 1 ♂, 3 ♀, 2 larvae, Oscar P. Estes (type collection); Aug. 20, 1958, 2 ♂, 1 ♀, 1 larva, T. C. Barr, Jr. Madison Cave, Aug. 23, 1958, 2 larvae, T. C. Barr, Jr. Bath Co.: Breathing Cave, part of Butler Cave on Sinking Creek, Aug. 28, 1958, 6 ♂, 7 ♀, 3 larvae; Porter's Cave, Aug. 27, 1958, 1 ♂, 2 ♀, 2 larvae; Star Chapel Cave, Aug. 29, 1958, 19 specimens, T. C. Barr, Jr.

WEST VIRGINIA: Greenbrier Co.: Higgenbotham Cave No. 4, Aug. 17, 1958, 8 ♂, 6 ♀, 2 larvae, T. C. Barr, Jr. Pendleton Co.: Mystic Cave, Aug. 31, 1958, 2 ♂, 2 ♀, T. C. Barr, Jr.

HISTORY: Dr. A. S. Packard made collections from Weyer's Cave in 1874 and from New Market and Luray Caves several years later. He first (1881) identified all of his specimens as *Spirostrephon copei* Packard, thinking that they were conspecific with the small white millipeds in Mammoth Cave, Kentucky. Later (1883, 1886) he changed his determination to *Zygonopus whitei*, but the description and figures that he published probably were not based on *Z. whitei*. He must have based them on his Weyer's Cave specimens, since Luray Cave is the type locality of *Z. whitei* and specimens from New Market Cave have been identified as *Z. whitei* (Loomis 1939).

He described the anterior gonopod as follows: "the outer lamina consists of a basal subtriangular portion, ending in a long, slender, curved spine, beneath which is a stouter spine, shorter and less curved; a minute median setose lamina is present, while the inner lamina is a weak, slender, setose filamentary outgrowth." The posterior gonopods were described as follows: "like those of *Trichopetalum*, the second (terminal) joint not ending in a claw."

***Zygonopus packardi*, new species**

Figures 8, 9

DIAGNOSIS: Distinguished by the characters of the anterior gonopod, especially by the two spinous coxites, which are contiguous at the base and very unequal in length. Nearest *Z. weyerienseis*, from which it can be distinguished by differences in the length, position and curvature of the coxites.

DESCRIPTION OF MALE HOLOTYPE: Length about 8 mm. The fourth and seventh segments of the sixth legpair are less inflated than in *Z. weyerienseis* (fig. 6); the seventh segment is narrowed and slightly sinuous.

A band of closely placed, scale-like setae crosses the anterior surface of the coxal region of the anterior gonopod (fig. 8); the setae are coarser than in *Z. whitei*. The three longer setae in the median row and the five or six on the disto-lateral margin of the coxa are straight and about the same length as in *Z. weyerienseis*. The two coxites, which are both spinous, are very close together at the base, the longer median one overlapping the shorter, stouter, lateral one; from a lateral view there is a small gap between them. The telopodite (fig. 9) is in the form of a thick, quadrate lamella with a thinner, triangular ventral lobe. The main plumose branch is very finely divided. A second, shorter plumose branch is partly covered by the lateral margin of the telopodite.

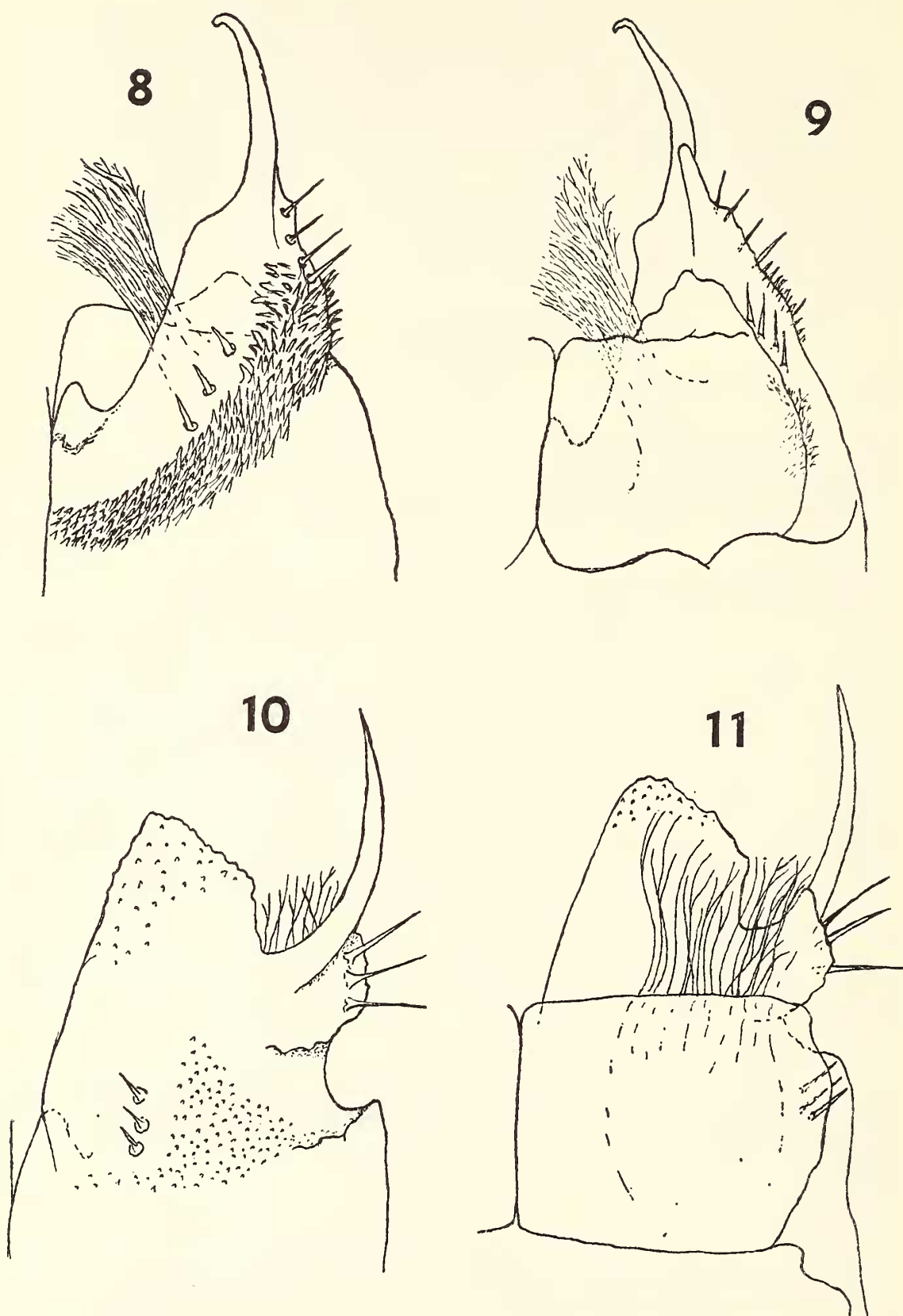
The posterior gonopod is composed of the usual two inflated, elongated segments and a minute terminal spine. The appearance is very much as in *Z. weyerienseis* (fig. 7).

VARIATIONS: Some variation was observed in the position of the coxites of the anterior gonopod, some being turned mesiad more than others; also, the shape of the triangular lobe on the ventral margin of the telopodite is slightly variable. The terminal spine of the posterior gonopod may be absent.

TYPE LOCALITY: Patton's Cave, Monroe County, West Virginia.

RANGE: Caves in Bland, Botetourt, and Giles Counties, Virginia; Greenbrier, Monroe and Mercer Counties, West Virginia; and Estill County, Kentucky. The Kentucky record may prove to be a custodial error, since no other Kentucky collections have been made.

RECORDS: VIRGINIA: Bland Co. Hamilton Cave, near Mechan-



FIGS. 8, 9. *Zygonopus packardi*, new species. 8. Right anterior gonopod, anterior view. 9. Left anterior gonopod, posterior view. Drawn from male paratype.

FIGS. 10, 11. *Zygonopus krekeleri*, new species. 10. Right anterior gonopod, anterior view. 11. Left anterior gonopod, posterior view. Drawn from male paratype.

iesburg, Sept. 6, 1958, 6 ♂, 7 ♀, T. C. Barr, Jr. Botetourt Co.: Perry Saltpeter Cave, at Saltpeter on the James River, Aug. 24, 1958, 3 ♂, 3 ♀, T. C. Barr, Jr. Giles Co.: Hopkins Cave, 1 mile south of Narrows, Aug. 12, 1957, 1 ♂, 1 ♀, C. H. Krekeler, Tawney Cave, 1½ mile northeast of Maybrook, Aug. 11, 1957, 1 ♂, 2 ♀. Starnes Cave, near Pearisburg, Aug. 3, 1958, 19 specimens, T. C. Barr, Jr. Straley's Cave, Sept. 6, 1958, 2 ♂, 5 ♀, T. C. Barr, Jr. WEST VIRGINIA: Greenbrier Co.: Organ Cave, Aug. 1958, 15 specimens, T. C. Barr, Jr. Mercer Co.: Honaker Cave, 5 miles southwest of Glenlyn, Virginia, Aug. 12, 1957, 1 ♂, 1 ♀, C. H. Krekeler. Monroe Co.: Fletcher's Cave, near Gap Mills, Aug. 8, 1958, 24 adult and larval specimens, T. C. Barr, Jr. Patton's Cave, 2 miles southeast of Gap Mills, Aug. 7, 1957, 5 ♂, 3 ♀, C. H. Krekeler (type collection); Aug. 8, 1958, 36 specimens, T. C. Barr, Jr.

This species is named for Dr. A. S. Packard, Jr., the founder of the science of cave biology in the United States.

***Zygonopus krekeleri*, new species**

Figures 10, 11

DIAGNOSIS: Distinguished by the anterior gonopod, which has a broad, membranous median coxite and a longer, spinous lateral coxite.

DESCRIPTION OF MALE HOLOTYPE: Length about 8.5 mm. Fourth segment of the sixth legpair slightly more bowed and the last segment slightly thinner than in *Z. weyeriensi*s (fig. 6).

The median coxite of the anterior gonopod is membranous and broad, and the lateral coxite is spinous and curved (fig. 10). A small area on the anterior surface of the coxa is covered with minute setae, and the distal part of the membranous lobe is sparsely setose. The longer setae in the median row of three and the three on the disto-lateral lobe of the coxa are straight. The telopodite (fig. 11) is in the form of a thick, quadrate lamella. The plumose branch is broad, so short that it is scarcely visible from an anterior view, and the fibrillae are sinuous and sparsely branched. A second, shorter plumose branch can be seen under the telopodite.

The posterior gonopod is composed of the usual two inflated, elongated segments; there is no terminal spine. The appearance is very much as in *Z. weyeriensi*s (fig. 7).

TYPE LOCALITY: Alpena Cave No. 1, Alpena, Randolph County, West Virginia.

RANGE: Caves in Randolph and Tucker Counties, West Virginia.

RECORDS: WEST VIRGINIA: Randolph Co.: Alpena Cave No. 1,

Alpena, July 20, 1957, 8 ♂, 9 ♀, C. H. Krekeler (type collection). Tucker Co.: Bennett Cave, 2 miles northeast of Gladwin, July 20, 1957, 2 ♂, 3 ♀, C. H. Krekeler.

It is a pleasure to name this species for Dr. Carl H. Krekeler.

RECORDS OF COLLECTIONS OF *Zygonopus* WITHOUT MATURE MALES:

WEST VIRGINIA: Greenbrier Co.: Pollock Caves, 3½ miles north-northeast of Alderson, Aug. 10, 1957, larvae, C. H. Krekeler. Monroe Co.: Argobrita Cave, 3 miles southeast of Wolf Creek, Aug. 10, 1957, 2 ♀, C. H. Krekeler. Pocahontas Co.: Martha Clark's Cave, near Marlinton, Aug. 15, 1958, 1 fragment, T. C. Barr, Jr. Randolph Co.: Crawford Cave, 3½ miles southwest of Valley Head, July 23, 1957, 2 ♀, C. H. Krekeler.

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